CHEMISTRY:

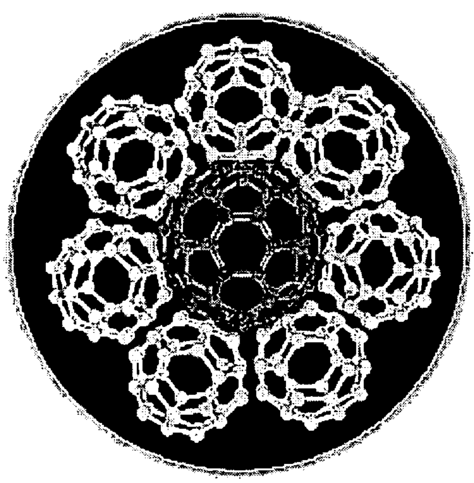
New Fullerene Rounds Out the Family

Robert F. Service

Materials scientists could soon be playing a new ball game. For more than a decade, they have been struggling to turn the 60-carbon soccer balls called buckminsterfullerenes into new materials and compounds. Now, researchers at the University of California, Berkeley, report in this week's issue of *Nature* that they've isolated a smaller fullerene sphere that contains just 36 carbon atoms. Tests on the new fullerene show that it is far more chemically reactive than its larger cousin, which could make it easier to fashion into everything from high-temperature superconductors to high-strength materials.

Researchers have known for years that the carbon-rich gases from which C_{60} and other, larger, fullerenes condense also contain a 36-carbon form. But the gases normally yield so little C_{36} that researchers had never been able to isolate and examine it. The Berkeley group's success is "really heroic," says James Heath, a chemist at the University of California, Los Angeles, who was part of the team that originally discovered fullerenes in 1985.

The researchers--physicists Charles Piskoti and Alex Zettl, along with chemist Jeff Yarger--started by passing a strong electric arc between a pair of carbon electrodes, in a vacuum chamber containing a whiff of helium. This creates a carbon vapor in which fullerenes of many different sizes take shape, along with piles of carbon soot. When they boosted the helium concentration, Zettl and his colleagues found they got a sharp rise in the production of C_{36}. The helium is thought to cool the vaporized carbon quickly, preserving fullerenes as they form.



Buckyball's little brother. C_{36} (yellow) is the first fullerene to have fewer carbons than the original (blue).

PISKOTI *ET AL.*

After that, "the main hurdle was purifying the C_{36}," says Piskoti, a graduate student in Zettl's lab. The Berkeley team tried two different strategies, both of which worked. In one, they drenched the soot in toluene, a solvent that dissolves and removes C_{60} and C_{70}, then placed the semipurified soot on a tungsten tray and heated it rapidly to about 1500 degrees Celsius. The larger soot particles were unaffected, while the smaller C_{36} molecules evaporated and condensed onto another metal surface above, forming a thin film of pure C_{36}. In their second approach, members of Zettl's team searched until they found other solvents--in this case pyridine and carbon disulfide--that could selectively dissolve C_{36} from the semipurified soot.

After isolating bulk samples of their new fullerene, Zettl and his colleagues took nuclear magnetic resonance spectra to determine the shape of the molecule. Its appearance--like a slightly squashed sphere--bears out theoretical predictions of the most stable closed structure 36 carbons can form. The group also found that these new fullerenes are very reactive and quickly decompose in air, says Piskoti.

This reactivity, due to the strained bonds in the sharply curved structure, could make C_{36} hard to handle, because separate molecules quickly bond together in a jumbled mass. But it could also turn out to be a blessing. Because C_{60} itself is fairly inert, disturbing its structure with additional chemical groups often results in a less stable product. But because C_{36} is unstable to start with, linking other atoms to it could yield stable new substances, which the molecule's unusual structure could endow with useful optical and electronic properties.

Among those properties might be superconductivity. C_{60} can act as a superconductor when it is doped with rubidium, but it loses its superconductivity above 31 kelvin--far below the 135-K record for high-temperature superconductors. But theories suggest that C_{36} should be able to do much better, perhaps even beating today's best ceramic superconductors. Zettl's group is pushing ahead to find out. It's a safe bet that they'll soon have a fair amount of company.

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